Education Outreach: The Crowd Source Clouds Data

GLOBE Clouds (S'COOL) Current Status

J. Brant Dodson

15 May 2018

Outline

1. General status of GLOBE Clouds
2. Scientific investigations with GLOBE Clouds and CERES data

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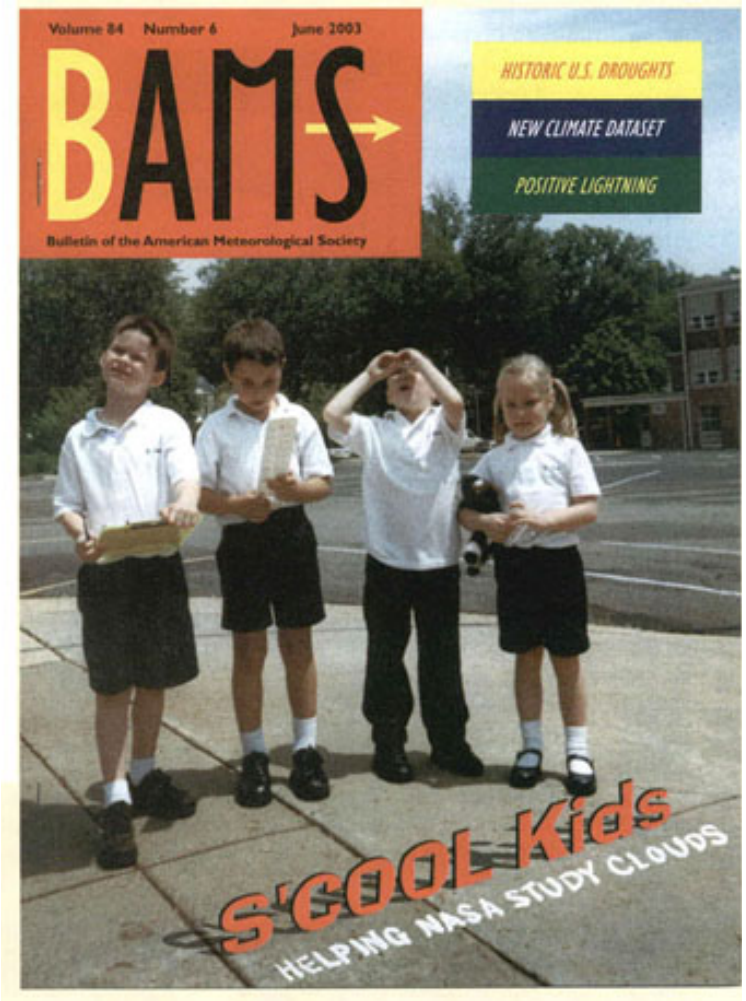
1. General status of GLOBE Clouds
2. Scientific investigations with GLOBE Clouds and CERES data

Over 20 years of citizen science data



The cover of the Jun 2003 issue of BAMS.

Since 1997, the S'COOL program gathered student cloud observations to provide ground truth measurements to provide validation for the CERES instrument.

S'COOL Report Form

Login ID: ______________________ **City:** ________________________

Date (ex. 2001 09 20): **Year** _ _ _ _ **Month** _ _ **Day** _ _ **Satellite:** ________________________

Local Time (24 Hour Clock: ex. 14 26): **Hour** _ _ **Minute** _ _ **Universal Time: Hour** _ _ **Minute** _ _

Students were asked to time obs. with satellite overpasses

Cloud Observations: (Select the most prevalent cloud type at each level where clouds exist. Cloud Cover and Visual Opacity must be determined for each level observed. Use the comment section for further descriptions.)

❑ **Clear Sky - No clouds observed**

High Level

Persistent

Short-Lived

Number of Persistent Contrails Present _____ **Number of Short-Lived Contrails Present** _____

Cloud Type:

- ❑ **Cirrus**
- ❑ **Cirrocumulus**
- ❑ **Cirrostratus**

Cloud Cover:

- ❑ Clear (0-5%)
- ❑ Partly Cloudy (5% - 50%)
- ❑ Mostly Cloudy (50% - 95%)
- ❑ Overcast (95% - 100%)

Visual Opacity:

- ❑ Opaque
- ❑ Translucent
- ❑ Transparent

Mid Level

Cloud Type:

- ❑ **Altostratus**
- ❑ **Altocumulus**

Cloud Cover:

- ❑ Clear (0-5%)
- ❑ Partly Cloudy (5% - 50%)
- ❑ Mostly Cloudy (50% - 95%)
- ❑ Overcast (95% - 100%)

Visual Opacity:

- ❑ Opaque
- ❑ Translucent
- ❑ Transparent

Low Level

Cloud Type:

- ❑ **Fog**
- ❑ **Stratus**
- ❑ **Nimbostratus**
- ❑ **Cumulus**
- ❑ **Cumulonimbus**
- ❑ **Stratocumulus**

Cloud Cover:

- ❑ Clear (0-5%)
- ❑ Partly Cloudy (5% - 50%)
- ❑ Mostly Cloudy (50% - 95%)
- ❑ Overcast (95% - 100%)

Visual Opacity:

- ❑ Opaque
- ❑ Translucent
- ❑ Transparent

Ground Observations:

Surface Cover:

Yes	*No*	
❑	❑	Snow/Ice
❑	❑	Standing Water
❑	❑	Muddy
❑	❑	Dry Ground
❑	❑	Leaves on Trees

Surface Measurements: (Optional data)

Temperature:

_____ Celsius or

_____ Fahrenheit

Barometric Pressure: (Select one)

_____ **hPa** _____ psi

_____ mb _____ inches Hg

_____ atm _____ torr (mm Hg)

Relative Humidity: _____ %

Comments:

S'COOL is now NASA GLOBE Clouds

NASA GLOBE Cloud Protocol

- Cloud News
- Teacher's Guide - Clouds
- How To Participate
- Satellite Overpass Times
- Observe and Report
- Satellite Comparison
- Explore Data
- Resources
- Contact NASA Science Team
- Cloud Protocol

GLOBE Cloud Protocol Featuring NASA Satellite Comparison

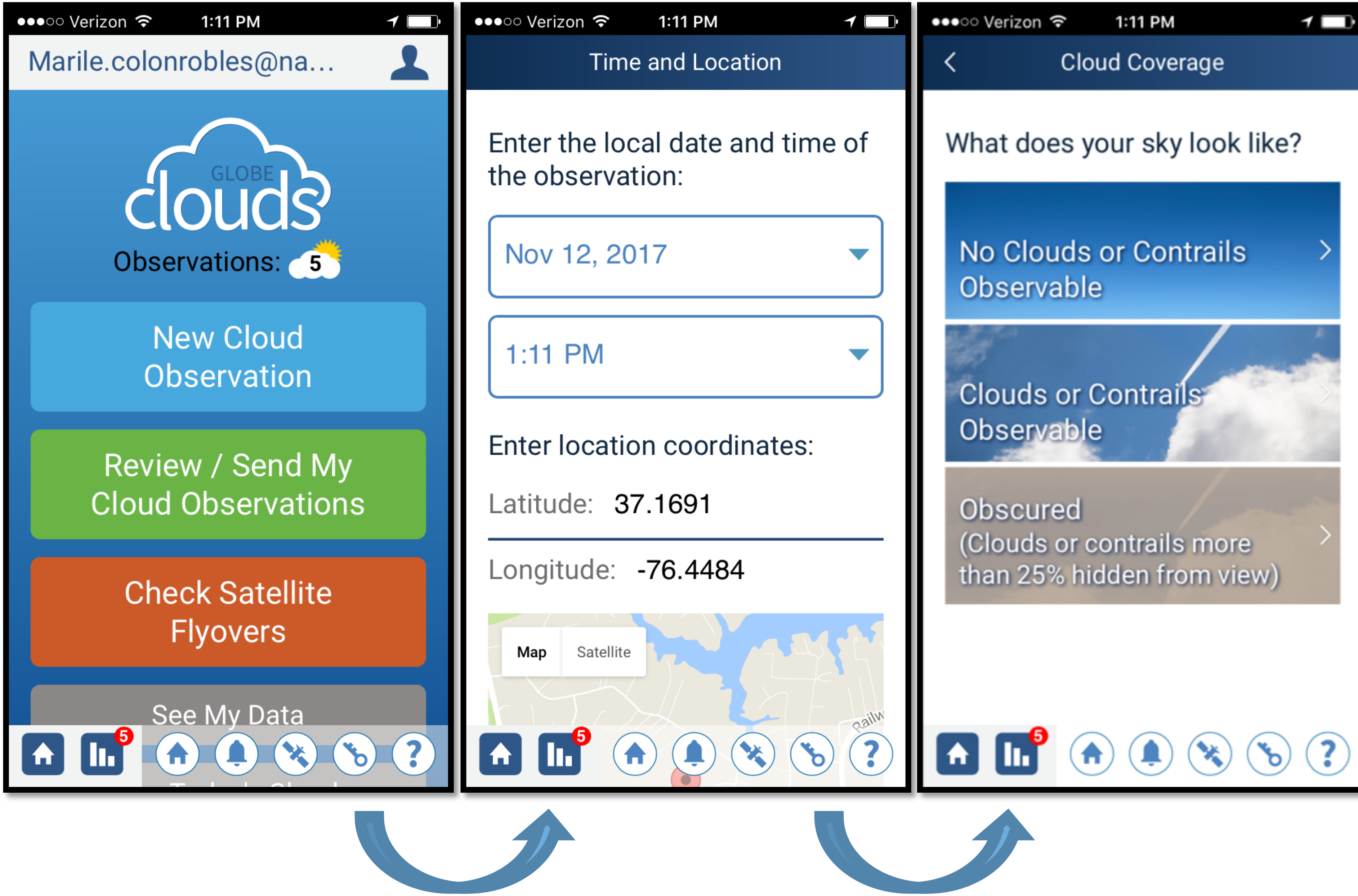
Clouds are powerful agents of global change. They affect the overall temperature or energy balance of the Earth and play a large role in controlling the planet's long-term climate.

To understand the impact of clouds over time, we need accurate data on clouds. NASA has a number of satellites orbiting the Earth and collecting data about clouds and the Earth's energy. While these satellites give us a big picture of what's going on, they sometimes have trouble with the details.

Now we need your help in collecting data so we can better understand the different types of clouds and the effects they have on our Earth's climate. Plus we need data from your vantage point- right here on Earth. Satellites only see the top of the clouds while you see the bottom. By putting these two vantage points together we get a much more complete picture of clouds in the atmosphere.

***The role of clouds in climate is complex, they cool the Earth's surface by reflecting sunlight and warm it by radiating and trapping heat". –* NASA's CERES Principal Investigator Norman Loeb**

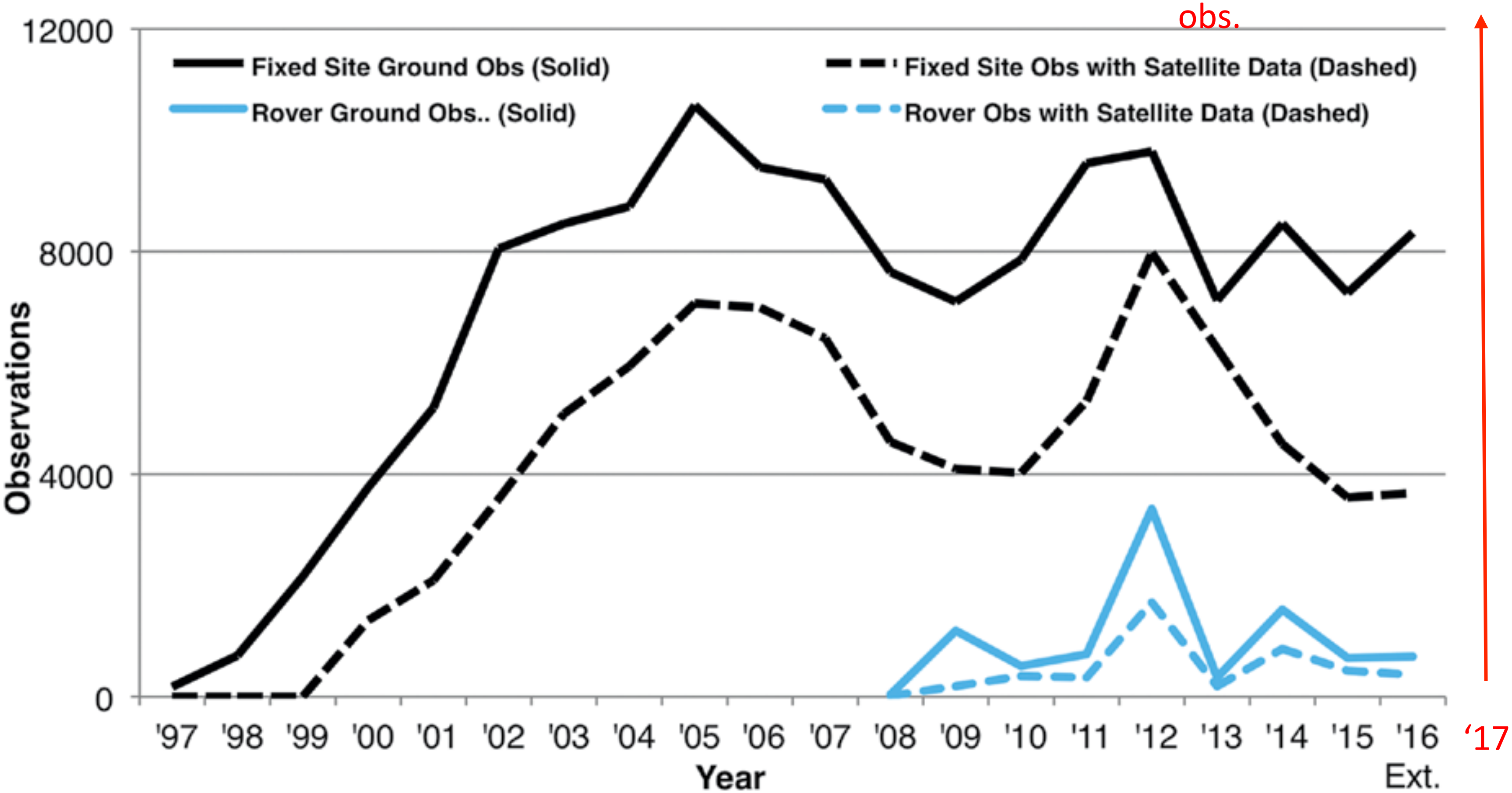
https://www.globe.gov/web/s-cool



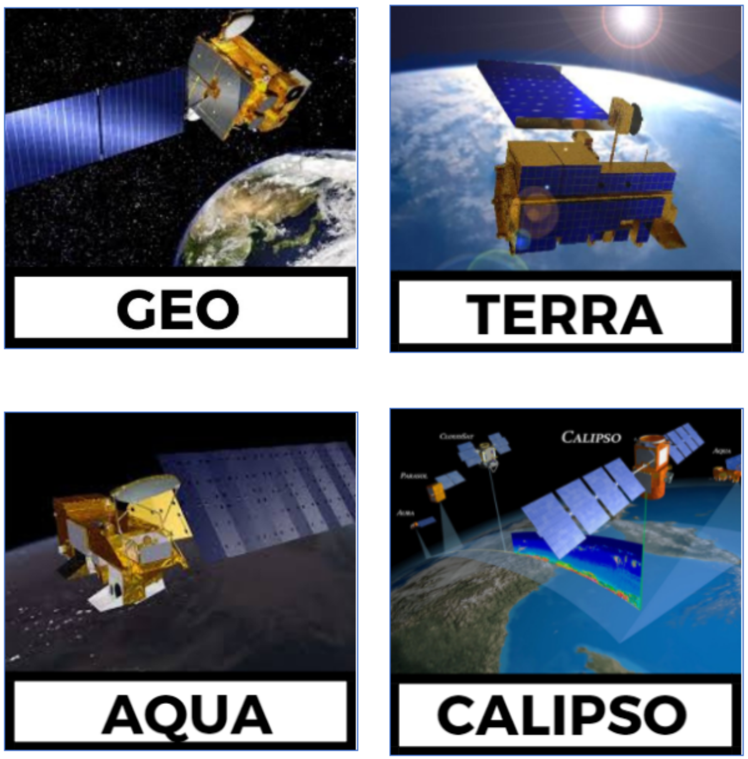
Download the GLOBE Observer app - https://observer.globe.gov/about/get-the-app

Citizen Science Remains Strong for over a Decade

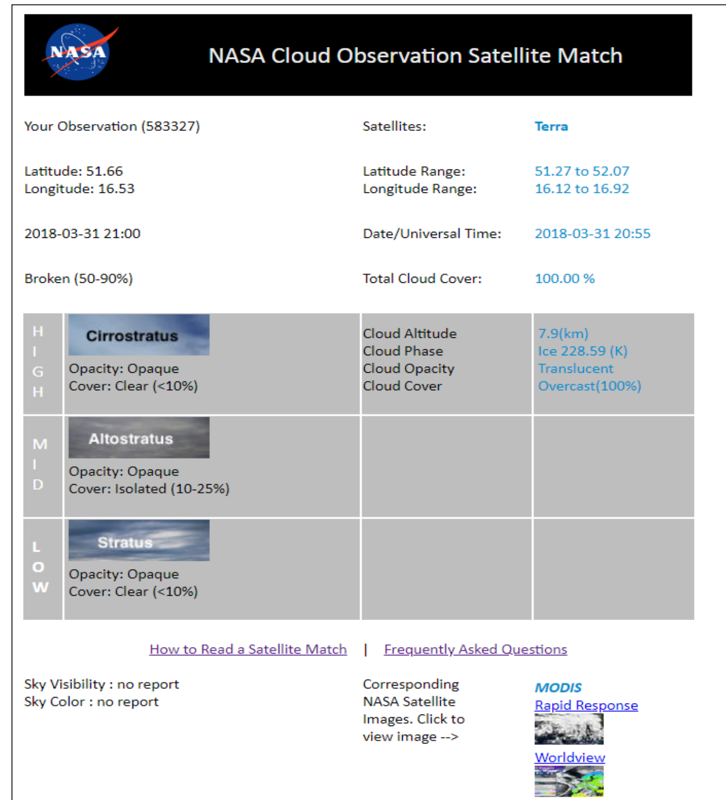
144,543 Obs.
96,129 matches
~equal to total # of S'COOL obs.



GLOBE Clouds Satellite Matching



Observations within ± 15 minutes and within a defined lat/long area are matched to satellite data.



NASA Cloud Observation Satellite Match

Your Observation (583327)		Satellites:	Terra
Latitude: 51.66 Longitude: 16.53		Latitude Range: Longitude Range:	51.27 to 52.07 16.12 to 16.92
2018-03-31 21:00		Date/Universal Time:	2018-03-31 20:55
Broken (50-90%)		Total Cloud Cover:	100.00 %
HIGH	Cirrostratus Opacity: Opaque Cover: Clear (<10%)	Cloud Altitude Cloud Phase Cloud Opacity Cloud Cover	7.9(km) Ice 228.59 (K) Translucent Overcast(100%)
MID	Altostratus Opacity: Opaque Cover: Isolated (10-25%)		
LOW	Stratus Opacity: Opaque Cover: Clear (<10%)		

How to Read a Satellite Match | Frequently Asked Questions

Sky Visibility : no report
Sky Color : no report

Corresponding NASA Satellite Images. Click to view image -->

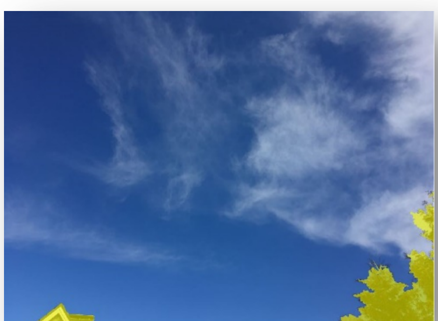
MODIS
Rapid Response
Worldview

An email is sent to the observer showing how their observations matched to satellite data.

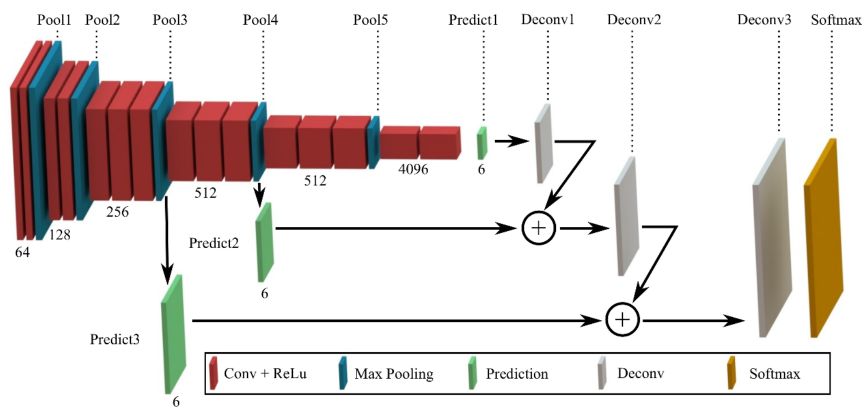
Classifying Cloud Types with Neural Networks

Input

Raw Image



Pre-Process Image



Process Image in Neural Network

Output

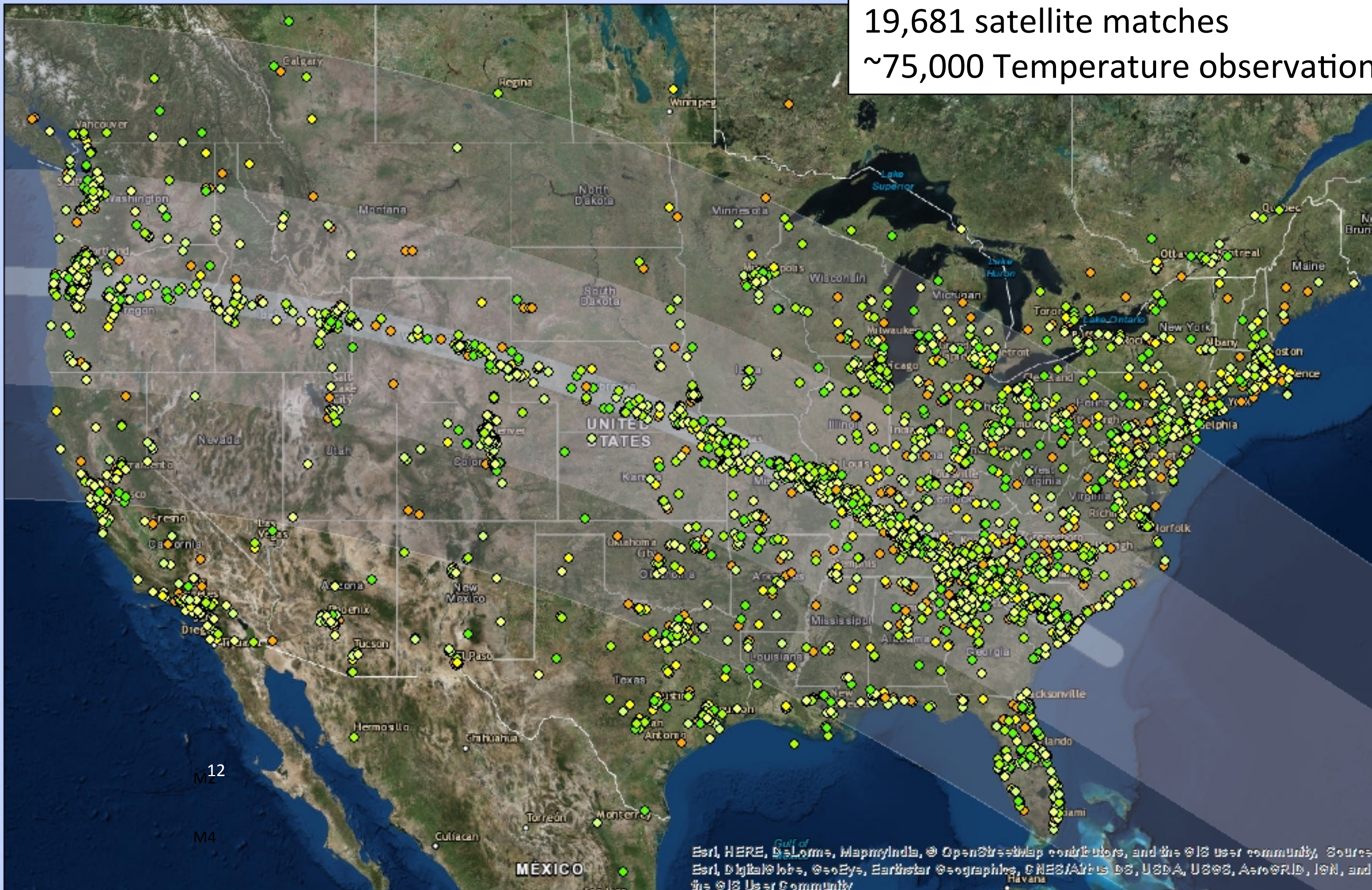
Cloud Type: Cirrus

Obtain cloud type proposal

“Great American” Total Solar Eclipse 2017

Eclipse 2017

20,369 cloud obs.
19,681 satellite matches
~75,000 Temperature observations



M2 12

M4

Percent Obscuration

- Totality
- Penumbra90
- Penumbra75

Time Range (minutes)

- 61 - 86
- 87 - 111
- 112 - 138
- 139 - 162
- 163 - 198
- 199 - 240

0 470 940 1,880 Kilometers

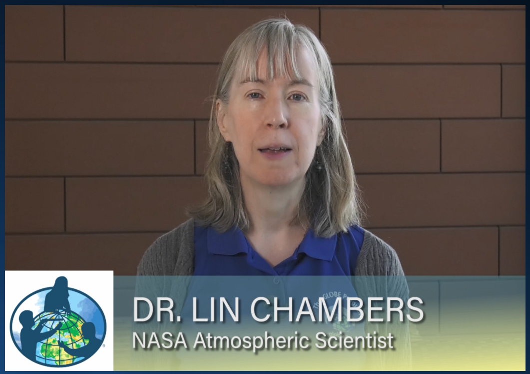
N

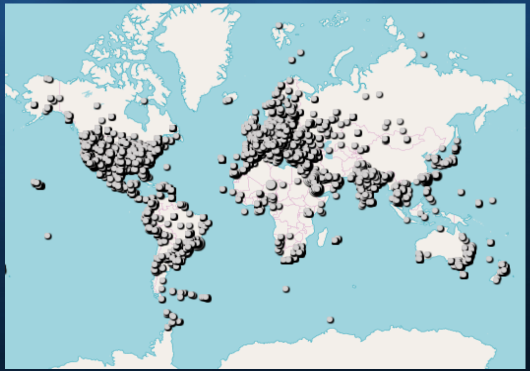
Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
Datum: WGS 1984
False Easting: 0.0000
False Northing: 0.0000
Central Meridian: 0.0000
Standard Parallel 1: 0.0000
Auxiliary Sphere Type: 0.0000
Units: Meter

Author: Travis Andersen

August 21, 2017

GLOBE Clouds Data Challenge (March 15 – April 15) Finale and Congratulatory Video



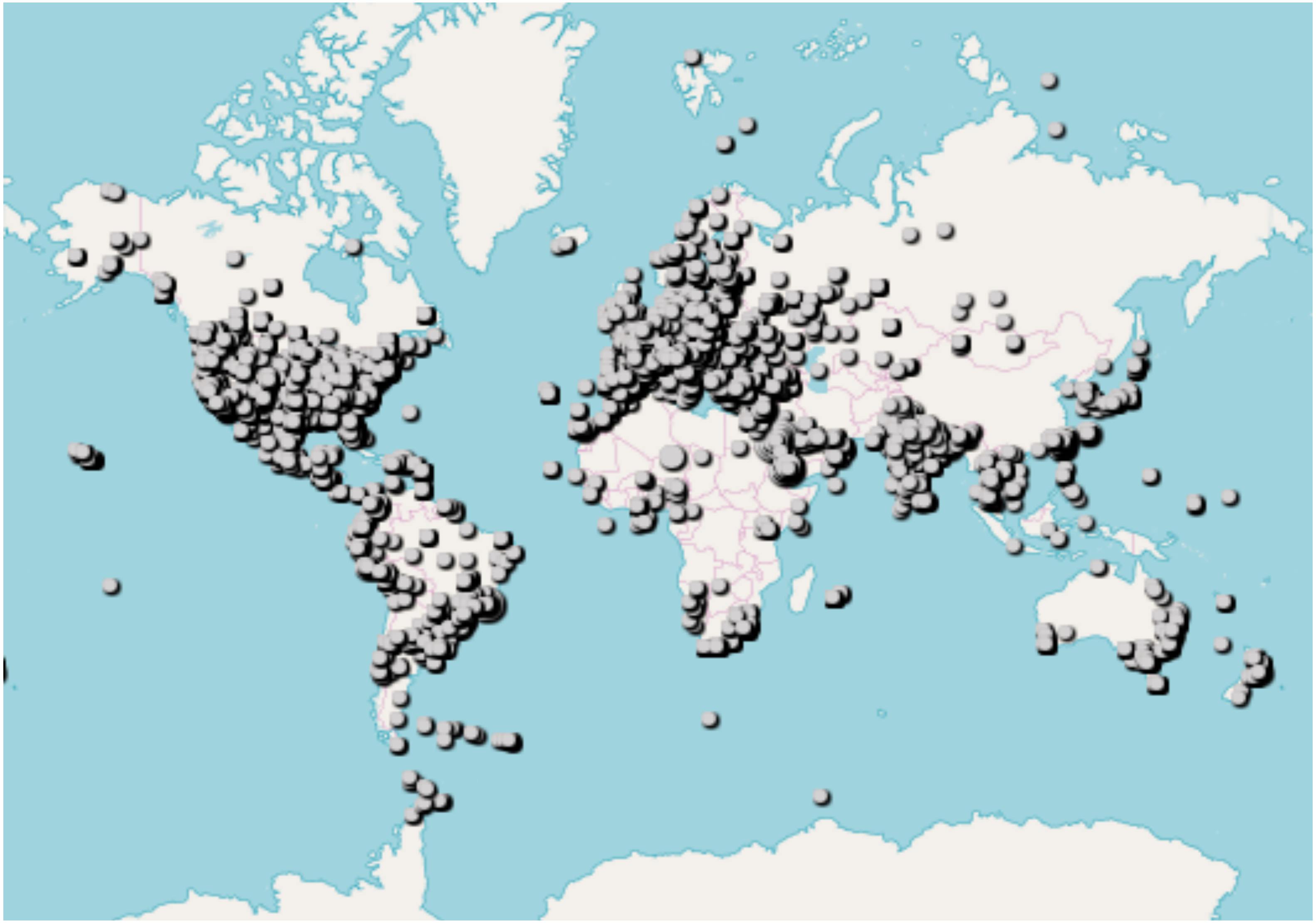


- 55,185 observations taken in one month
  - compare with ~10,000 per year from S'COOL, 100,000 from GLOBE
- 33,974 satellite matches
- Major public interest and media recognition
- No natural phenomenon (e.g. solar eclipse), but public responded enthusiastically
- If professional scientists need ground observations to address specific scientific questions in the future, citizen scientists will respond

https://www.nasa.gov/feature/langley/nasa-to-cloud-gazing-citizen-scientists-job-well-done

Jessica Taylor, NASA Langley Research Center,
NASA Earth Science Education Collaborative (NESEC)
Jessica.e.taylor@nasa,gov

Data Challenge Observer Locations



all seven continents, including Antarctica

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1. General status of GLOBE Clouds
2. Scientific investigations with GLOBE Clouds and CERES data

CERES versus S'COOL – Two Major Studies

6.2 STUDENTS AS GROUND OBSERVERS FOR SATELLITE CLOUD RETRIEVAL VALIDATION

Lin H. Chambers, P. Kay Costulis, David F. Young
NASA Langley Research Center, Hampton, VA

(2004)

Tina M. Rogerson
Science Applications International Corporation, Hampton, VA

CERES S'COOL PROJECT UPDATE

(2017)

The Evolution and Value of a Long-Running Education Project with a Foundation in NASA Earth Science Missions

Lin H. Chambers, Megan A. McKeown, Sarah A. McCrea,
Ann M. Martin, Tina M. Rogerson, and Kristopher M. Bedka

CERES versus S'COOL – Main Findings

- CERES and S'COOL agreed on presence of clouds 87% of the time
- Major disagreement in cloud cover often occurred from S'COOL spatial mismatches at the edge of CERES grid boxes; some time errors as well
  - improvements in space/time matching has led to improvements in agreement
- S'COOL transparency estimates correspond with CERES optical depth estimates
- Major disagreements in cloud layers occurred when observer saw single unbroken low cloud layer when satellite saw high clouds above
- Snow was not a major factor in causing major disagreements

CERES versus S'COOL - Cloud Type

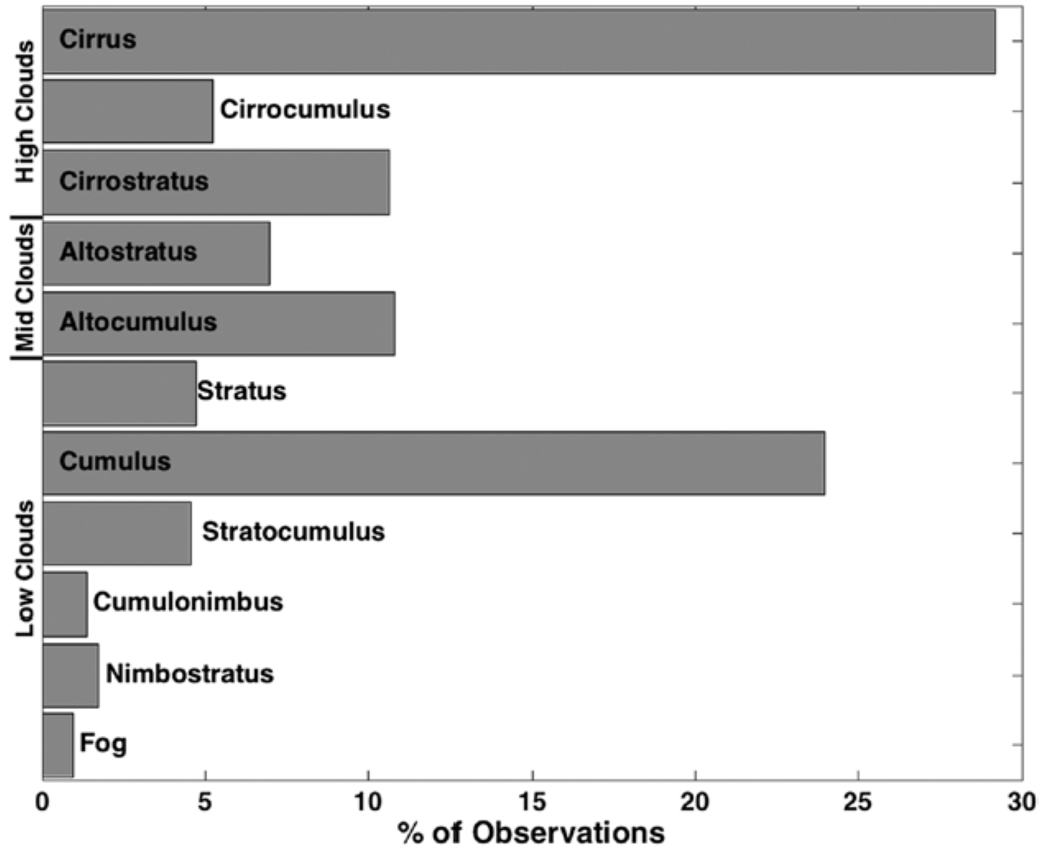

FIG. 5. Frequency of occurrence for each cloud type reported by S'COOL observers when the CERES algorithm failed to detect any clouds present. Cirrus (and other cirroform) and cumulus clouds are the most frequently missed cloud types.

Chambers et al. 2017

Two Main Scientific Questions for GLOBE Clouds

1. Can we better characterize the conditions in which GLOBE clouds and CERES disagree?
2. How much do newer cloud detection algorithms and merged sensor cloud products (e.g. C3M) improve the satellite cloud estimates over CERES alone for situations where CERES has difficulty?

We are in the planning stages for identifying the scientific possibilities of GLOBE Clouds

Observing thin (subvisible) cirrus

Contrails

Clouds below cloud/aerosol layers

Help us design the next GLOBE Clouds Data Challenge!

Marilé Colón Robles, SSAI
NASA Education Specialist/GLOBE Clouds Lead

Tina Rogerson, SSAI
Scientific Programmer/ Analyst

Dr. Jason (Brant) Dodson, SSAI
Research Scientist

Cayley Cruickshank DeFontes
NIFS Data Science Intern

Contact the team
https://scool.larc.nasa.gov/GLOBE/contact/
Or
Marilé directly at Marile.ColonRobles@nasa.gov
Brant directly at Jason.B.Dodson@nasa.gov

CERES S'COOL PROJECT UPDATE

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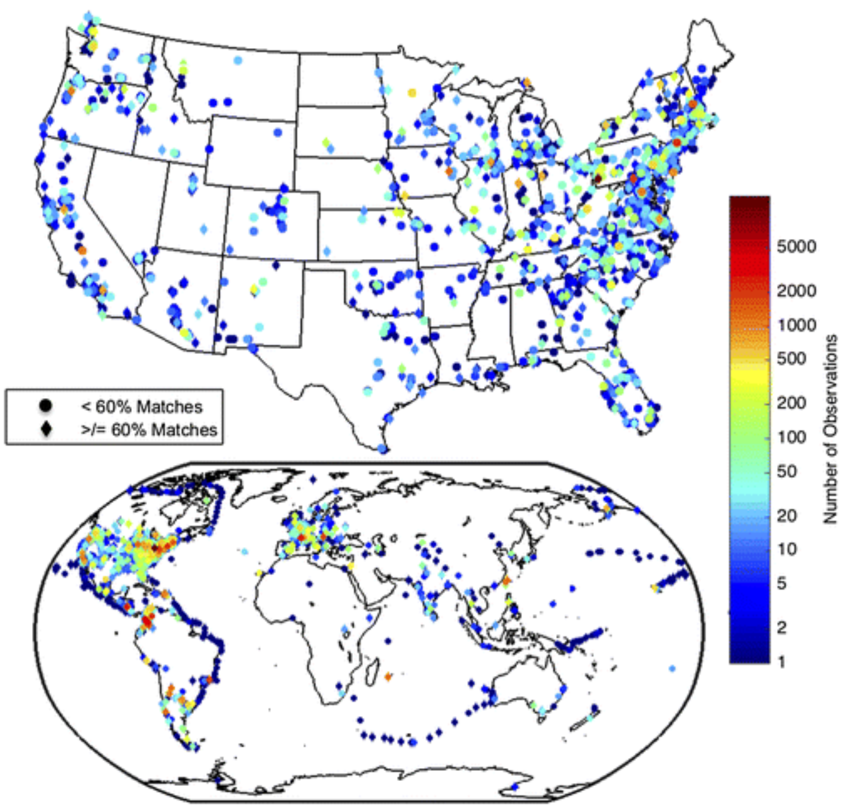


S'COOL Project participation around the globe.

BAMS article (March 2017) addressing scientists concerns about accuracy of crowd-sourced data.

Using 72,501 S'COOL-MODIS matches, authors found ***87.2% agreement*** between ground observations and satellite detection.

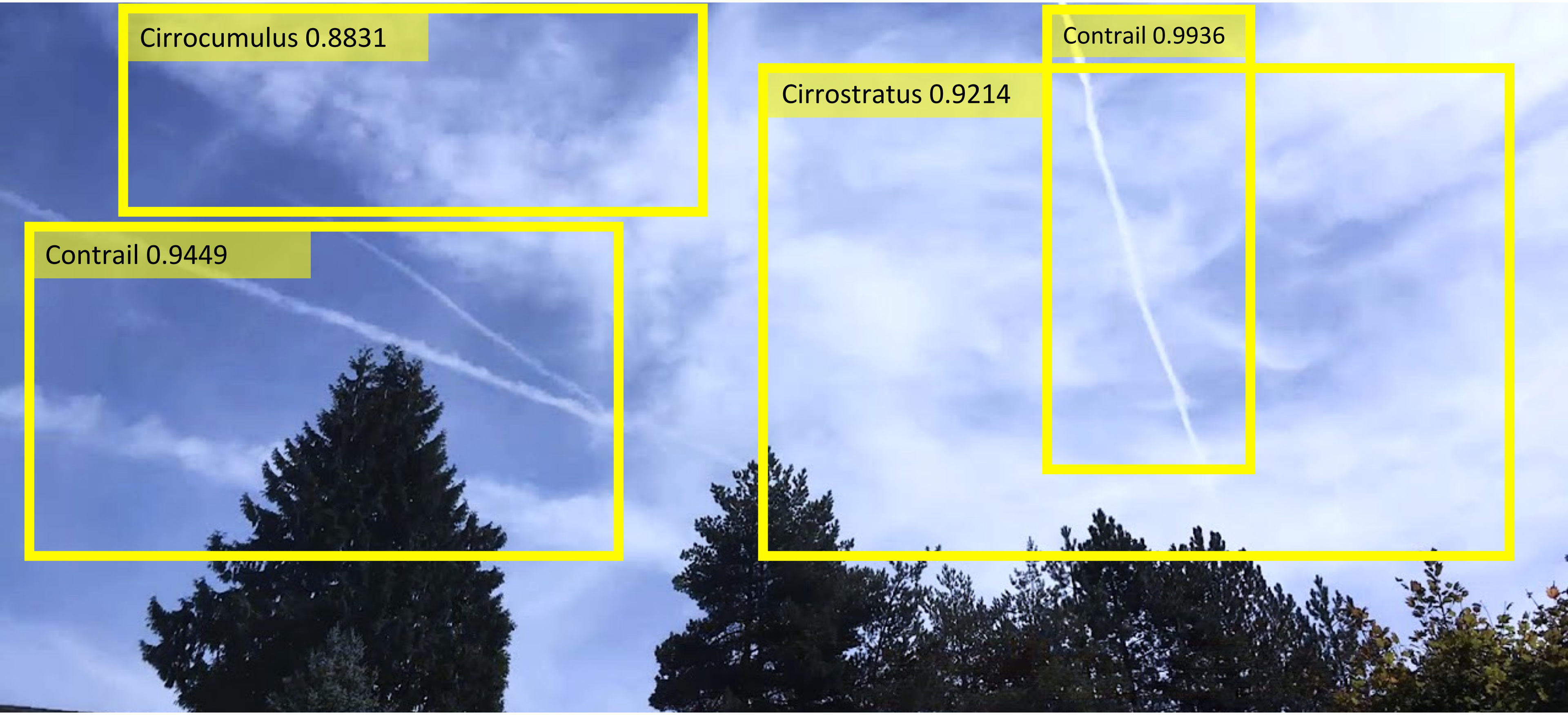
MODIS–CALIPSO cloud detection comparisons also show an agreement of ***87%*** providing confidence in S'COOL observers' ability to discern and accurately report the presence of clouds.

NGC-Net: NASA GLOBE Clouds Program Cloud Recognition Network

- **NGC-Net (NASA GLOBE Clouds-Network) is a convolutional neural network created to identify cloud types from ground-based images uploaded to the GLOBE Observer platform by citizen scientists and NASA GLOBE Clouds Program participants.**
- **NGC-Net is built on VGG-16 architecture and contains 41 total layers to classify 8 distinct cloud categories.**
- **Network obtained 97.88% validation accuracy when trained on 4,800 ground-based images from GLOBE Observer mobile application users.**

Object Class	Class Description	Number of Images Trained per Class
Cirrus	Cirrus	600
Cumulus, High level	Cirrocumulus	600
Stratus, High level	Cirrostratus	600
Cumulus, Mid/Low levels	Altocumulus, Stratocumulus, Cumulus	600
Stratus, Low/Mid levels	Altostratus, Stratus, Nimbostratus	600
Cumulonimbus	Cumulonimbus	600
Contrails	Short-lived, Persistent-Non Spreading, Persistent Spreading	600
Clear Sky	Clear sky (no clouds)	600
8 Total Categories		**4,800 Total Images**

Image uploaded via GLOBE Observer of clouds observed in Redmond, Washington.



6.2 STUDENTS AS GROUND OBSERVERS FOR SATELLITE CLOUD RETRIEVAL VALIDATION

Lin H. Chambers, P. Kay Costulis, David F. Young
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Tina M. Rogerson
Science Applications International Corporation, Hampton, VA

1. INTRODUCTION

The Students' Cloud Observations On-Line (S'COOL) Project was initiated in 1997 to obtain student observations of clouds coinciding with the overpass of the Clouds and the Earth's Radiant Energy System (CERES) instruments on NASA's Earth Observing System satellites. Over the past seven years we have accumulated more than 9,000 cases worldwide where student observations are available within 15 minutes of a CERES observation.

This paper reports on comparisons between the student and satellite data as one facet of the validation of the CERES cloud retrievals. Available comparisons include cloud cover, cloud height, cloud layering, and cloud visual opacity. The large volume of comparisons allows some assessment of the impact of surface cover, such as snow and ice, reported by the students.

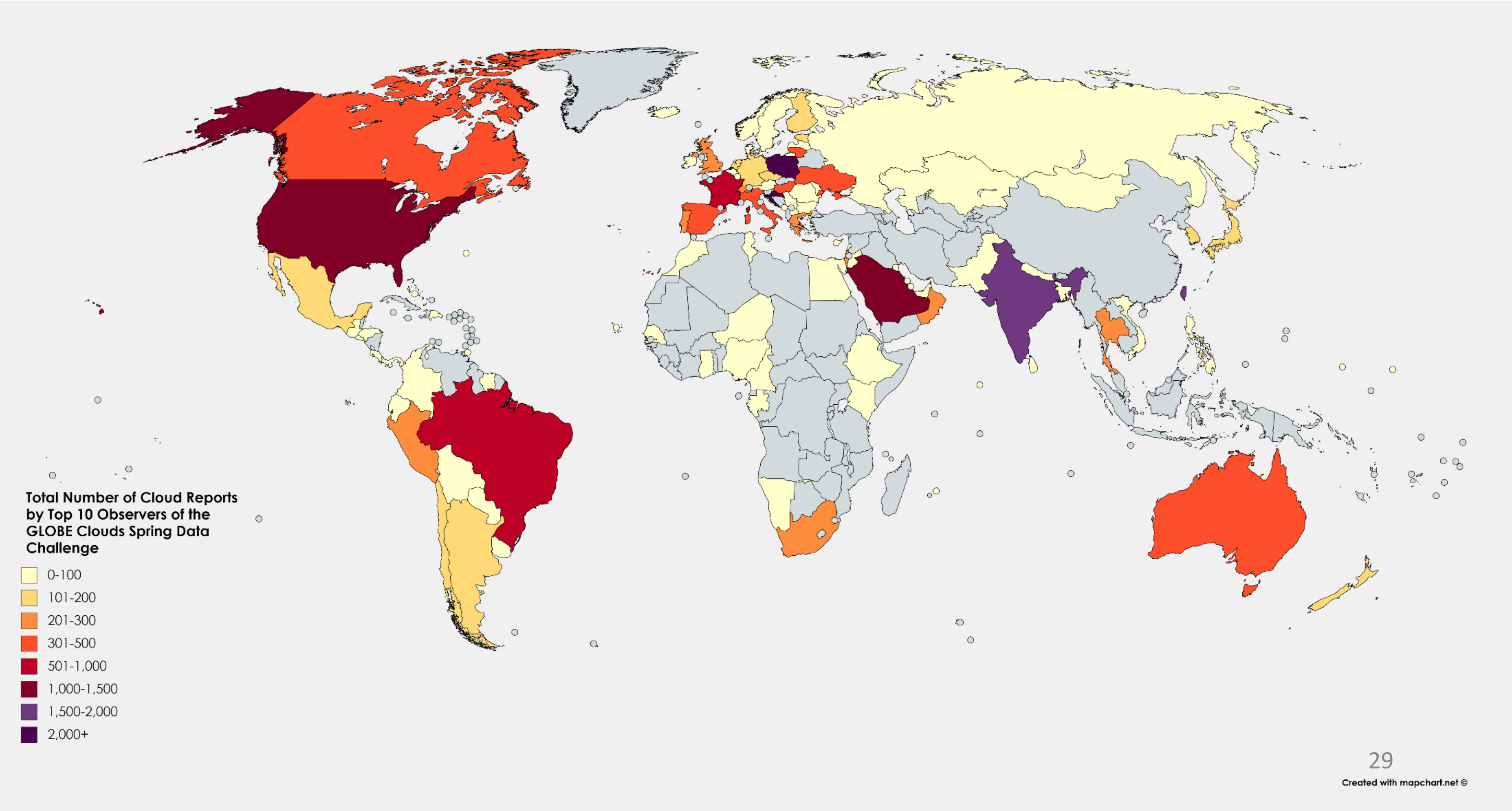
The S'COOL observation database, accessible via the Internet at http://scool.larc.nasa.gov, contains over 32,000 student observations and is growing by over 700 observations each month. Some of these observations may be useful for assessment of other satellite cloud

3. INITIAL COMPARISONS

Following the first year of operation (1998) of the first CERES instrument launched on the Tropical Rainfall Measuring Mission (TRMM) spacecraft, and the subsequent processing of the CERES data, an initial comparison of student to satellite data was performed. Because TRMM is a precessing satellite that allowed the CERES instrument to view only the Tropics (~35 S to 35 N), and because the initial network of S'COOL schools was primarily in North America and Europe, very few ground to satellite correspondences were available. A correspondence is defined as a ground observation that occurs within 15 minutes of a satellite observation, and it is compared in this study to the average properties obtained by the satellite for the 1-degree region containing the ground site. The 50 or so correspondences for CERES TRMM were augmented with about 50 geostationary satellites images that were manually processed through CERES-like cloud algorithms for some of the higher latitude observations. In these cases, a box was drawn somewhat subjectively around the school site. Tables 1 and 2 present the

Lin et al. 2004

of Observations from Highly-productive Observers by Nation



CERES S'COOL PROJECT UPDATE

The Evolution and Value of a Long-Running Education Project with a Foundation in NASA Earth Science Missions

LIN H. CHAMBERS, MEGAN A. MCKEOWN, SARAH A. MCCREA,
ANN M. MARTIN, TINA M. ROGERSON, AND KRISTOPHER M. BEDKA

Since 1997, S'COOL has engaged interested participants worldwide in observing clouds and comparing data from ground and satellite sources to inform validation efforts for several NASA Earth science missions.

Scientists are increasingly interested in crowd-sourced data but have concerns about its accuracy. Begun nearly 20 years ago, the Students' Cloud Observations Online (S'COOL) project, introduced to *BAMS* readers in Chambers et al. (2003), offers a

ity to inform this question. S'COOL

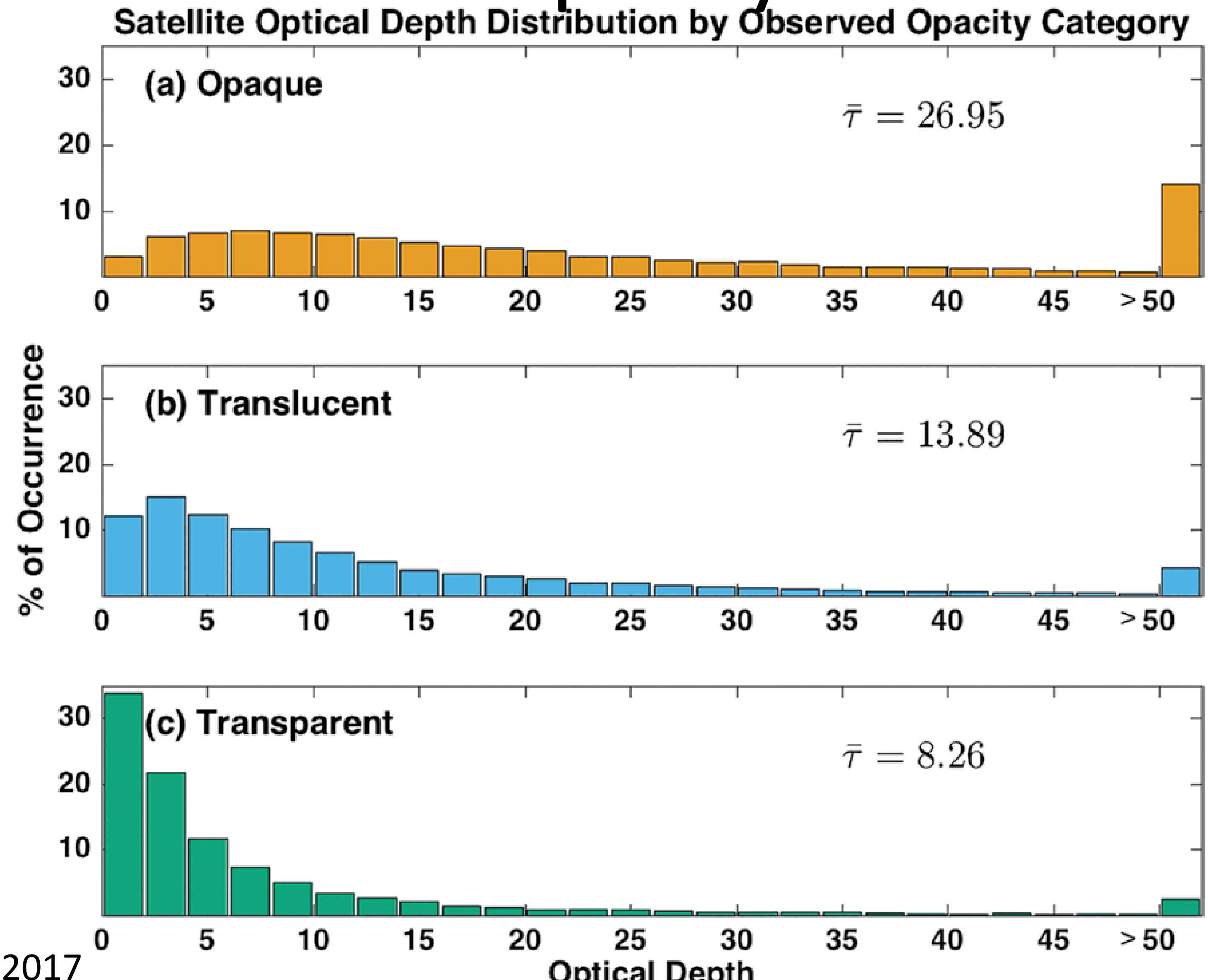
nfluence of education and science

based data on clouds. Here we examine the record of participation and the information gathered to assess the value of crowd-sourced Earth system data and to illuminate important considerations for scientists considering involving a wider community in their work.

Imager-based cloud retrievals (cloud/no cloud and cloud properties such as phase, optical depth, and

Lin et al. 2017

CERES versus S'COOL Cloud Opacity



Lin et al. 2017

CERES versus S'COOL Cloud Cover

Table 3. Cloud cover from satellite vs. ground observers

		Ground Observers			
		Clear	Partly	Mostly	Overcast
S	Clear	1125	254	87	45
A	Partly	799	955	583	231
T	Mostly	297	585	700	681
	Overcast	154	193	490	1993

Table 4. Cloud layers from satellite vs. ground observers

		Ground Observers		
		No Cloud	Single	Multi
S	No Cloud	950	615	100
A	Single	306	2030	581
T	Multi	249	3306	1035

- CERES and S'COOL agreed in roughly half of cases (52% and 44%)
- Major disagreement in cloud cover often occurred from S'COOL spatial mismatches at the edge of CERES grid boxes; some time errors as well
- Major disagreements in cloud layers occurred when observer saw single unbroken low cloud layer when satellite saw high clouds above
- Snow was not a major factor in causing major disagreements

Lin et al. 2004